Design Considerations for Earth Stations to Operate with Anik C3 Satellite

Telesat

Telesat Canada

New Horizons in Communications

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Notes:

This design workbook has been prepared to provide a methodology for the design of earth stations to receive television signals from Telesat's Anik C3 satellite. The introduction provides an overview of Telesat's Anik C3 satellite system which distributes a variety of television services including Pay TV. The workbook section is a step by step guide to designing earth stations for the reception of signals from Anik C3. The supplementary data in the back pocket provides the necessary technical information.

ANIK C SATELLITE SYSTEM

The Anik C series of communication satellites is positioned in a geostationary orbit above the equator and operates in the 14/12 GHz frequency band. Each satellite utilizes two orthogonally polarized repeaters and by the reuse of the frequency spectrum has a capacity of 16 transponders, each one having a usable bandwidth of 54 MHz. Two separate video services can be transmitted in each transponder, thus achieving a total capacity of 32 video services on each Anik C satellite. An RF channel is defined to be any one of two 27 MHz segments in a 54 MHz transponder (Fig. 1).

The uplink antenna coverage for both repeaters is obtained by single shaped antenna beams. Linear orthogonal polarization, using a shared reflector aperture, provides the necessary isolation between the two uplink beams (Fig. 2)

The downlink antenna coverage area (Fig. 3) is divided into four 1/4 Canada regions across Canada, each region being approximately 2 degrees East-West by 1 degree North-South as viewed from synchronous orbit.

The two 1/4 Canada Western regions are served by one repeater, while the two 1/4 Canada Eastern regions are served by a second. Within each repeater, RF switches can combine the eastern or western quarter Canada beams to provide half-Canada coverage. Note: quarter Canada coverage can only be assured if both customers sharing a transponder require the same quarter Canada coverage. Should one of the customers elect to increase his coverage to half-Canada, or should the customer be replaced by another with half-Canada coverage requirements, Telesat, in the interest of maximizing satellite utilization will be obliged to increase the coverage area for both customers. It would be prudent, therefore, when designing for a quarter Canada beam, to give due consideration to the performance of the earth station, in the event that the coverage be changed to a half Canada beam.

Attachment 1 consists of a set of typical EIRP contours for both 1/2 Canada coverage, and for 1/4 Canada coverage. These result from Anik C3 being positioned at 117.5 degrees West.

Notes:

Figure 1

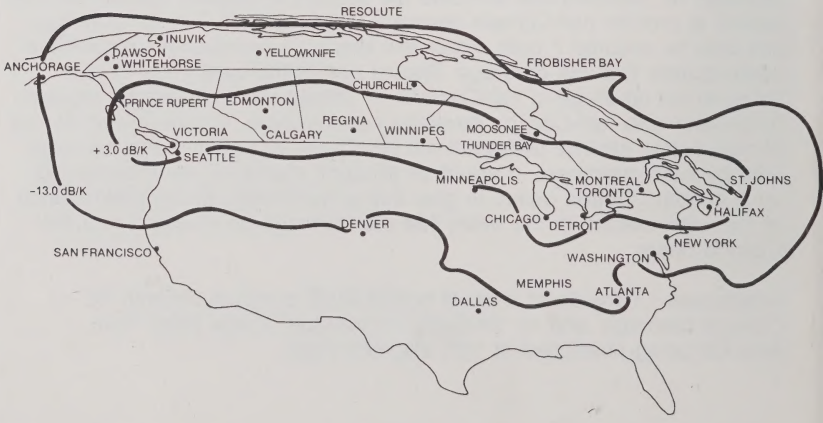
ANIK C 14/12 GHz FREQUENCY & POLARIZATION PLAN

VERTICAL POLARIZATION — WEST BEAM

HORIZONTAL POLARIZATION — EAST BEAM

FIGURE 2

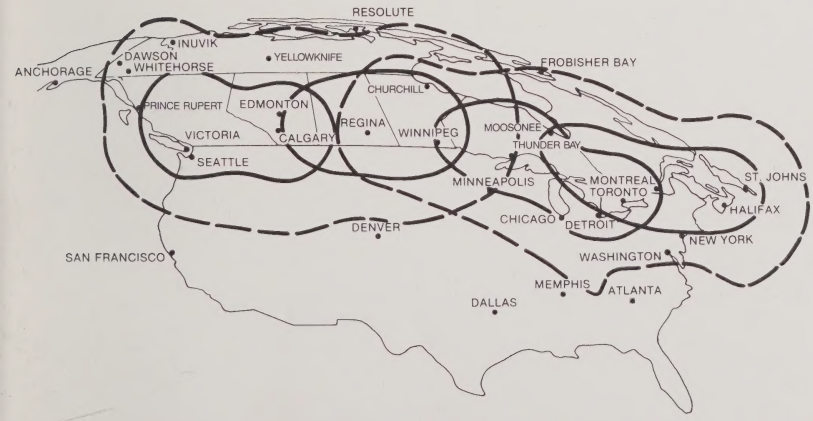
ANIK C 14 GHz UPLINK PATTERN (G/T – TYPICAL)



Notes:

Figure 3

ANIK C 12 GHz DOWNLINK PATTERN (EIRP-TYPICAL)



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Earth Station Design

Due to rapid advances in technology the intent of this workbook is not to comment on individual equipment selection. Rather this guide hopes to ensure that basic earth station design, together with satellite signal strength, will result in the desired level of performance.

The format employed for transmission normally incorporates two television transmit services in one transponder. The RF signal strength corresponding to this format is reflected in the typical EIRP contours supplied with this document. The 'typical' contours are channel 4H in the East and channel 4V in the West. At some locations variations of up to $\pm$ 3dB are possible between channels. If the actual channel of interest is known, specific contours are available from Telesat. In addition to the EIRP contours, a tabulation is provided for every major city, listing certain losses as a function of the environment and the geographic location, and the percentage of time for which these losses are exceeded. In assembling this step by step guide, certain assumptions and generalizations had to be made in order to produce a usable tool. The following methodology will identify the earth station antenna size for most requirements, and can be used as a starting point from which the design can be tailored to a specific application.

STEP 1 REQUIRED S/N RATIO

Decide on the clear weather Signal to Noise (S/N) ratio required at the receiver output.

The following may serve as a guide:

50 dB S/N may be required for a large system with many tandem elements

48 dB S/N for a medium sized system,

45 dB S/N for a small system

The S/N ratio above is defined as the peak-to-peak signal to rms weighted noise ratio measured in a 4.2 MHz bandwidth.

Example:

A requirement exists in the Halifax area for a receive-only earth station that is to deliver a 48 dB signal-to-noise ratio under clear weather conditions. It is required to estimate the necessary antenna diameter to achieve this quality, and to assess the performance under fade conditions. The channel of interest is channel 4H.

The satellite is located at 117.5° W, operating in the 2 carrier per transponder format, and covers Halifax in a half Canada beam.

Notes:

Notes:

STEP 2 REQUIRED CLEAR WEATHER CARRIER-TO-NOISE (C/N) RATIO

Derive the required clear weather C/N ratio for the location in question.

When operating above threshold, the S/N is related to the C/N by the FM improvement (FMI) and weighting factors. The FM improvement, on the other hand, is related to the frequency deviation of the video signal. Addition of audio subcarriers requires the reduction of video deviation to maintain the same signal bandwidth, and hence results in a reduction in FM improvement.

In the current Anik C design, high level audio (HLA) services impress an approximate 2 MHz peak deviation on the video carrier. Low level audio (LLA) services are generally companded, and impress an approximate 1 MHz peak deviation on the video carrier.

The following table provides the FM improvement and weighting factors relating the S/N ratio to the C/N ratio as a function of audio services, and deviation for Anik C3.

TABLE 1

Baseband Signal	Video Deviation	FM Improvement Plus Weighting
1 V + 1 HLA	9.0 MHz	34.2 dB
1 V + 1 HLA + 2 LLA	8.5 MHz	33.2 dB
1 V + 1 HLA + 5 LLA	7.5 MHz	32.2 dB

V – NTSC video baseband signal
HLA – High level audio (2 MHz deviation of main carrier)
LLA – Low level audio (Companded – 1 MHz deviation of main carrier)

$$S/N \text{ dB} = C/N \text{ dB} + (FMI + \text{Weighting}) \text{ dB}$$

Example:

The service to be received consists of a video signal plus 1 high level audio signal, and 2 low level audio signals.

The FM improvement is estimated from Table 1 to be 33.2 dB. As the required S/N ratio is 48 dB, the resulting clear weather C/N ratio is calculated as follows:

S/N dB = C/N dB + (FMI + Weighting) dB

ie. 48 dB = C/N dB + 33.2 dB

or C/N dB = 14.8 dB (clear weather)

STEP 3 DETERMINE DOWNLINK C/N RATIO

Notes:

Table 2 provides the numbers used to calculate a typical uplink carrier to thermal noise ratio. Based on reasonable assumptions of adjacent satellite EIRP levels, earth station antenna sidelobe performance, intermodulation products and finite polarization isolation, a typical carrier to interference noise ratio is calculated in Table 3. Knowing the required total C/N ratio from Step 2, the downlink C/N ratio can then be calculated as follows for 1/2 Canada coverage.

$$(C/N\ tot)^{-1} = (C/N\ up)^{-1} + (C/N\ int)^{-1} + (C/N\ dn)^{-1}$$

$$(C/N\ dn)^{-1} = (C/N\ tot)^{-1} - (C/N\ up)^{-1} - (C/N\ int)^{-1}$$

When C/N is expressed in dB, the following applies:

$$\left(\text{Antilog}\frac{C/N}{10}\ dn\right)^{-1} = \left(\text{Antilog}\frac{C/N}{10}\ tot\right)^{-1} - \left(\text{Antilog}\frac{C/N}{10}\ up\right)^{-1} - \left(\text{Antilog}\frac{C/N}{10}\ int\right)^{-1}$$

Example:

The total clear weather C/N ratio calculated in Step 2 above, is to some degree influenced by the uplink C/N ratio, and the cross polarized energy and interference signals from adjacent satellites. Inserting estimates of the uplink and interference contributions allows one to calculate the downlink C/N ratio.

The C/N tot was estimated in Step 2 as 14.8 dB

The C/N up for 1/2 Canada coverage from Table 2 is 22.8 dB

The C/N int for 1/2 Canada coverage from Table 3 is 21.3 dB

The C/N dn for the Halifax location can now be estimated

$$\left(\text{Antilog}\frac{C/N\ dn}{10}\right)^{-1} = \left(\text{Antilog}\frac{14.8}{10}\right)^{-1} - \left(\text{Antilog}\frac{22.8}{10}\right)^{-1} - \left(\text{Antilog}\frac{21.3}{10}\right)^{-1}$$

$$= .0331 - .0052 - .0074$$

$$= .0205$$

$$\text{Antilog}\frac{C/N\ dn}{10} = 48.7805$$

$$C/N\ dn = 10 \log 48.7805$$

$$= 16.9\ dB$$

Notes:

TABLE 2

Typical Uplink Carrier-to-Noise Ratio (C/N up)

	Unit	TV (1/4 Can)	TV (1/2 Can)
Satellite G/T	dB/K	3	3
Saturating Flux Density	dBw/m^2	−82	−82
Input Backoff per carrier	dB	8	8
Required Flux Density	dBw/m^2	−90	−90
C/N Thermal	dB–Hz	97.1	97.1
Noise Bandwidth	MHz	27	27
C/N up	dB	22.8	22.8

TABLE 3

Typical Adjacent Satellite Carrier-to-Interference Ratio (C/N int)

	Unit	TV (1/4 Can)	TV (1/2 Can)
Adjacent Satellite			
–Uplink	dB	30.92	30.92
–Downlink	dB	28.74	25.74
Adjacent Channel			
–Uplink	dB	29.0	29.0
–Downlink	dB	35.1	32.1
Cross-Polarization			
–Uplink	dB	26.9	26.9
–Downlink	dB	—	—
C/N int	dB	22.4	21.31

STEP 4 ESTIMATE THE DOWNLINK EIRP

The EIRP refers to the "effective isotropic radiated power," or the equivalent power transmitted from the satellite considering it as an omnidirectional source. The contours provided in Attachment 1 allow for the site location to be plotted and the expected EIRP to be estimated, by interpolation if necessary.

Example:

The EIRP contours for Halifax for 1/2 Canada coverage using the E + EC beam are provided in Figure 9 of Attachment 1. Note that the data is for a satellite located at 117.5° W, using the 2 TV carriers per transponder format.

For Halifax the expected EIRP is 43.0 dBw, in channel 4H.

STEP 5 DETERMINE THE PATHLOSS

The pathloss refers to the freespace loss experienced by the isotropic source from the point of radiation, to the point at which the spherical wavefront is intercepted by the receive antenna. It is therefore proportional to the range of the satellite from the point of interest.

Table 4 below lists the freespace loss from a satellite located at 117.5 W, to receive stations located at several Canadian cities. Sufficiently accurate results can be obtained by using the pathloss figure associated with the city closest to the point of interest.

Example:

From Table 4, the pathloss from a satellite located at 117.5° W to Halifax is 206.1 dB.

TABLE 4

Free Space Pathloss* at 12 GHz for Various Locations

Location	Satellite Position 117.5W
Halifax	206.1
St. John's	206.0
Fredericton	206.0
Montreal	205.9
Toronto	205.8
Sudbury	205.8
Winnipeg	205.8
Regina	205.7
Edmonton	205.8
Calgary	205.7
Vancouver	205.7

***NOTE:** Does not include atmospheric absorption losses.

STEP 6 ESTIMATE THE RECEIVER NOISE BANDWIDTH (NBW)

The receiver noise bandwidth is an important parameter of the receive system, and refers to the noise bandwidth presented to the receiver demodulator. The choice of bandwidth is a trade-off between threshold performance and baseband signal fidelity.

The noise bandwidth (NBW) of many receivers can be estimated by applying an approximate form-factor of 1.12 to the 3dB IF bandwidth of a typical receiver.

Example:

The half-power (3 dB) bandwidth of the receiver to be used is approxmately 24 MHz. The estimated noise bandwidth is therefore:

1.12 x 24 MHz = 26.88 MHz.

This is converted directly to 74.3 dB-Hz

STEP 7 CALCULATE REQUIRED G/T

The G/T, or gain-to-noise temperature ratio, of a receive terminal is the single most important parameter that describes the quality of the earth station as a receive terminal.

$$G/T\ (dB/K) = C/N\ dn - EIRP + Pathloss + NBW + k^*$$

* k (Boltzmann's constant) = –228.6 dBw/K-Hz

Example:

At the Halifax location:

The C/N dn was estimated in Step 3 as 16.9 dB

The EIRP at Halifax estimated in Step 4 is 43 dBw for channel 4H

The pathloss estimated in Step 5 is 206.1 dB

The noise bandwidth from Step 6 is 74.3 dB-Hz

Boltzmann's constant (k) relating the noise power to the noise temperature is –228.6 dBw/K-Hz

$$G/T(dB/K) = 16.9\,dB - 43\,dBw + 206.1\,dB + 74.3\,dB\text{-}Hz - 228.6\,dBw/K\text{-}Hz$$
$$= 25.7\,dB/K$$

Notes:

STEP 8 DETERMINE THE NOISE TEMPERATURE OF THE RECEIVE SYSTEM (T_{SYS})

The required G/T can best be achieved by selecting an appropriate low noise amplifier (LNA) and calculating the system noise temperature. The required antenna diameter can then be estimated.

The total noise temperature of the earth terminal (T_{SYS}) can be estimated by summing the contributions due to the LNA, the antenna as a function of elevation angle, and miscellaneous contributions resulting from mismatch, receiver noise figure, etc. A curve of antenna noise temperature versus elevation for a 1.8 m antenna is provided in Figure 4. Adequate accuracy can be obtained by using these figures initially. Upon estimating the necessary antenna diameter, the manufacturer's data can be inserted to confirm the adequacy of the system design.

$$T_{SYS} = T_{LNA} + T_{ANT} + T_{MISC}$$

$$T\,(dB) = 10 \log T\,(deg\ K)$$

Example:

The noise temperature of the receive system is estimated as follows:

a) Calculate the LNA noise temperature from the manufacturer's data. A good quality state-of-the-art LNA has a noise figure (NF) of 3.0 dB. The noise temperature can be calculated as follows;

$$\text{Noise temperature} = 290\,(\text{Antilog}\ \frac{NF}{10} - 1)$$

For a 3.0 dB unit

$$\text{Noise temperature} = 290\,(\text{Antilog}\ 0.3 - 1)$$
$$= 289\ K.$$

b) The elevation of Anik C3 from Halifax is 16.5 degrees (Table 5). Thus, a 1.8 m antenna would produce a noise temperature of approximately 38 K, based on the curve in Figure 4.

c) Additional noise contributions from the interfacility link (IFL) and receiver are approximately 20 K

d) The total system noise can then be estimated as follows;

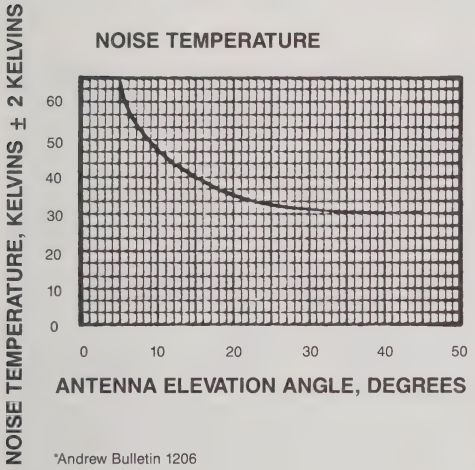
LNA	*289 K*
Antenna	*38 K*
Miscellaneous	*20 K*
TOTAL	*347 K*

This may be expressed in dB-K as follows;
10 log 347 K = 25.4 dB-K

FIGURE 4

Antenna Noise Temperature as a Function of Elevation

1.8m ANTENNA CHARACTERISTICS*



*Andrew Bulletin 1206

Operating Frequency, GHz	11.7 - 12.2
Polarization	Linear
Gain dB ± 0.2dB at 11.95 GHz	46.0
Noise Temperature, kelvins	
at 10° elevation	47
at 20° elevation	35
at 30° elevation	32
VSWR maximum	1.3
Isolation, dB	35
Half-Power Beamwidth, degrees	0.91
Pattern Envelope (PE) Number	3400
Output Flanges	WR-75

The Andrew 1.8 metre, 12 GHz receive only earth station antenna has been designed to achieve high gain. The use of the multi-mode corrugated feed together with the excellent reflector surface accuracy results in an antenna efficiency of 73%.

TABLE 5

Earth Station Coordinates for a Satellite Located at 117.5° W

Location	Azimuth (Deg)	Elevation (Deg)
Halifax	242.9	16.5
St. John	240.5	17.7
Fredericton	239.8	17.8
Montreal	233.7	22.4
Toronto	228.7	26.9
Sudbury	225.6	25.8
Winnipeg	206.1	29.8
Regina	196.7	30.9
Edmonton	185.3	28.9
Calgary	184.5	31.6
Vancouver	172.6	33.3

STEP 9 ESTIMATE ANTENNA DIAMETER

The required G/T was calculated in Step 7. The system noise temperature was calculated in Step 8.

The required antenna gain (G) = G/T + T_{SYS} in dB

The antenna diameter can be estimated by using the following formula:

$$\text{Gain (dB)} = 10 \log (109.7\ f^2 d^2 \eta)$$

Where f is the frequency in GHz
d is the diameter in meters.
η is the efficiency of the antenna.

Example:

The required G/T has to be 25.7 dB/K.
The system noise temperature is 25.4 dB-K
The required antenna gain is 25.7 dB/K + 25.4 dB-K = 51.1 dB

Manufacturers of receive-only antennas are presently able to achieve an efficiency of 70% for certain configurations in the 1.8 – 4.5 m range at 12 GHz.

Gain (dB) = 10 log (109.7 $f^2 d^2 \eta$)

where f is the frequency in GHz
d is the diameter in meters
η is the efficiency as a fraction

$$d^2 = \frac{\text{Antilog } G/10}{109.7\ f^2 \eta} \qquad f = 12,\ \eta = 0.7$$

$$= \frac{\text{Antilog } 51.1/10}{109.7\ (12)^2\ 0.7}$$

$$= 11.65\ m^2$$

$$d = 3.4\ m$$

The nearest standard antenna is 3.7 m or 12 feet with a typical gain of 51.4 dBi

STEP 10 CONFIRM PERFORMANCE

Attachment 2 lists the atmospheric absorption, rain attenuation, and satellite pointing losses for several Canadian cities, and the percentage of time for which those losses are exceeded.

By relating the tabulated figures to the already estimated clear weather C/N and S/N ratios an assessment of the link can be made under different conditions of propagation.

Example:

From the propagation statistics provided in Attachment 2, it can be estimated that the total downlink losses at Halifax exceed

1.9 dB for 1% of the time
2.5 dB for 0.5% of the time
and 4.9 dB for 0.1% of the time

It has previously been estimated in Step 3, that for 1/2 Canada coverage, the

C/N up is typically 22.8 dB
C/N dn is calculated to be 16.9 dB
and C/N int is estimated to be 21.3 dB

Using the following relationship, the downlink can be faded by the levels above, and the resulting C/N tot estimated.

$(C/N\ tot)^{-1} = (C/N\ up)^{-1} + (C/N\ dn)^{-1} + (C/N\ int)^{-1}$

For 1% of the time C/N tot = 13.6 dB
0.5% of the time C/N tot = 13.1 dB
0.1% of the time C/N tot = 11.2 dB

For the very special case, where the transmitter is co-located with the receiver, an uplink fade results in a reduction of the downlink EIRP. This downlink EIRP is further reduced by the downlink fade.

An estimate of the downlink EIRP reduction, $\triangle EIRP$, as a result of an uplink fade may be made from the knowledge of the expected downlink fade as follows:

The uplink fade, A_u, may be approximated as 1.5 × (downlink fade,dB)

$\triangle EIRP \cong A_u$ *when* A_u *is less than 0.3 dB*

$\triangle EIRP \cong 1/2\ A_u$ *when* A_u *is between 0.3 and 5dB*

$\triangle EIRP \cong A_u - 3$ *when* A_u *is greater than 5dB*

In deriving $\triangle EIRP$ it was assumed that there are two carriers on each RF channel each with 8 dB input backoff. In addition, it was assumed that both carriers experience the uplink fade.

To account for uplink fading, then, the C/N up should be reduced by the appropriate fade margin. The C/N dn should be reduced by the Δ EIRP as a result of the uplink fade, and in addition should be reduced by the downlink fade. The combined C/N tot is the expected condition under a simultaneous uplink and downlink fade. In this example it is found that for a co-located transmit and receive station in the Halifax area, operating on channel 4H, performance above threshold can be expected for all but 0.5% of the time. If this is unacceptable, performance should be reassessed using a 4.5m antenna.

DIRECT TO HOME SERVICE

All of the preceding discussions relate to a format wherein 2 TV carriers share a single 54 MHz bandwidth transponder. Good quality reception into antennas of 1 to 2m diameter is possible by using a single TV carrier per transponder. In such an application, the diameter of the required antenna can be estimated by ignoring the uplink C/N ratio, and assuming that the downlink C/N ratio is increased by 5 dB.

This workbook has been prepared to provide a methodology, for the design of earth stations for receiving television signals from Telesat's Anik C3 satellite. Examples used in this workbook are for illustrative purposes only. Telesat accepts no liability with respect to the use of any of the information contained herein, as it is based upon certain assumptions and may be subject to change.

Attachment 1

Typical EIRP Contours for both 1/2 Canada Coverage and 1/4 Canada Coverage for Channel 4H

The contours provided allow for the site location to be plotted and the expected EIRP to be estimated by interpolation if necessary.

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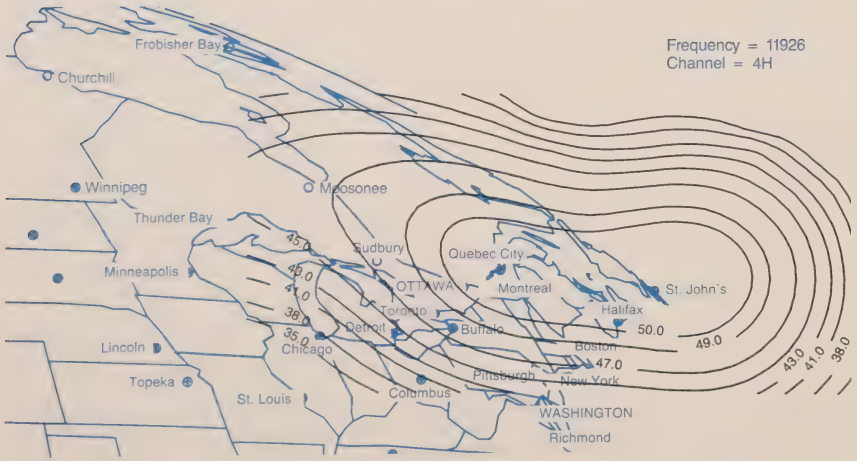
Figure No	Sat Pos'n	Coverage	Transmission Mode
1	117.5°	1/4 CAN (E)	1 TV (0db OPBO)
2	117.5°	1/4 CAN (EC)	1 TV (0db OPBO)
3	117.5°	1/2 CAN (E/EC)	1 TV (0db OPBO)
4	117.5°	1/4 CAN (W)	1 TV (0db OPBO)
5	117.5°	1/4 CAN (WC)	1 TV (0db OPBO)
6	117.5°	1/2 CAN (W/WC)	1 TV (0db OPBO)
7	117.5°	1/4 CAN (E)	2 TV (5db OPBO)
8	117.5°	1/4 CAN (EC)	2 TV (5db OPBO)
9	117.5°	1/2 CAN (E/EC)	2 TV (5db OPBO)
10	117.5°	1/4 CAN (W)	2 TV (5db OPBO)
11	117.5°	1/4 CAN (WC)	2 TV (5db OPBO)
12	117.5°	1/2 CAN (W/WC)	2 TV (5db OPBO)

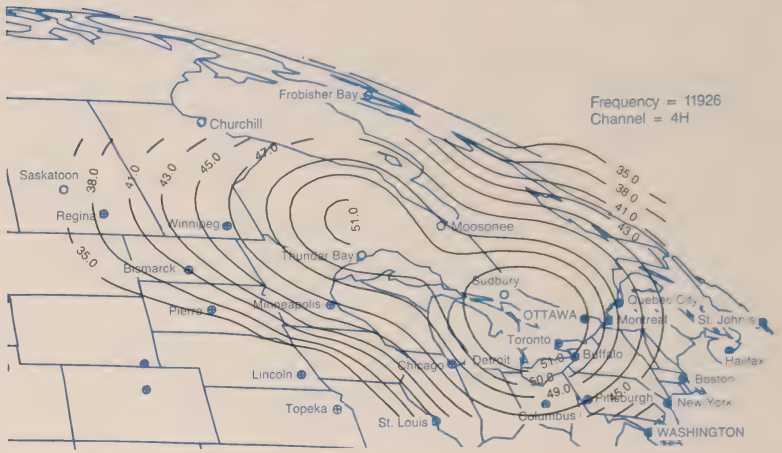
Figure 1
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/4 CANADA EAST (E) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one video service using a full transponder (54 MHz) operating in a 0dB output power backoff mode.

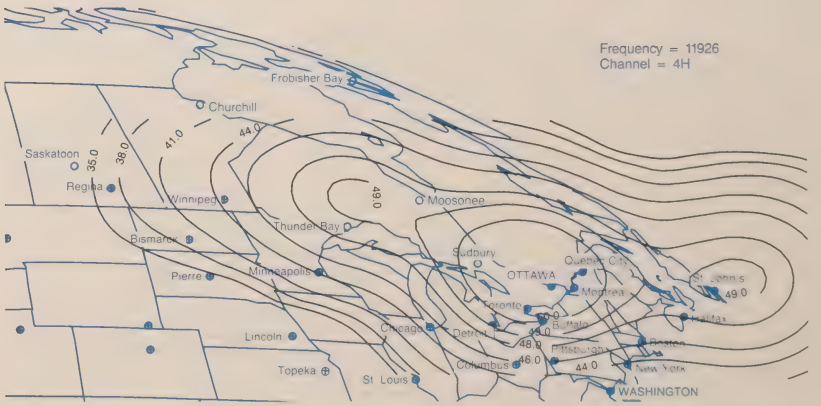
Figure 2
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/4 CANADA EAST-CENTRAL (EC) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one video service using a full transponder (54 MHz) operating in a 0dB output power backoff mode.

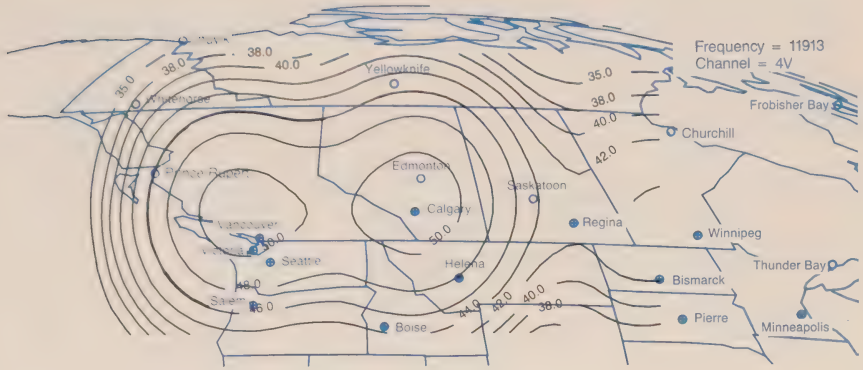
Figure 3
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/2 CANADA COMBINED EAST/EAST-CENTRAL (E/EC) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one video service using a full transponder (54 MHz) operating in a 0dB output power backoff mode.

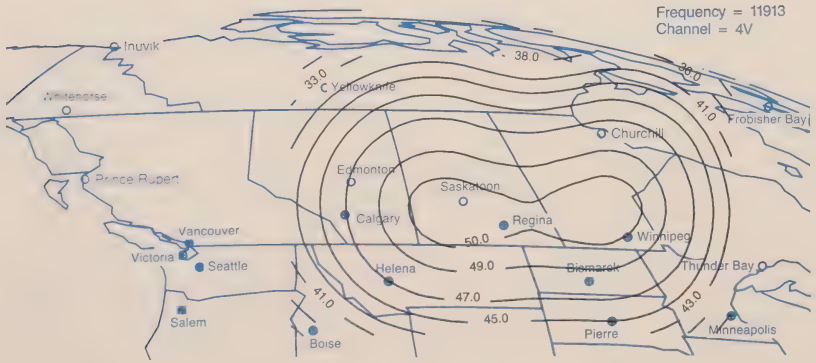
Figure 4
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/4 CANADA WEST (W) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one video service using a full transponder (54 MHz) operating in a 0dB output power backoff mode.

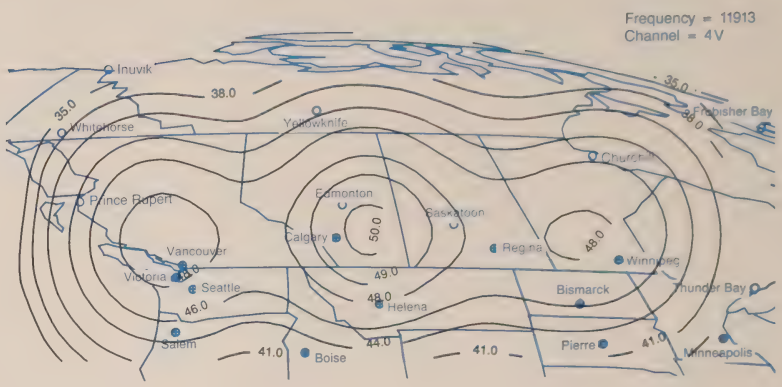
Figure 5
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/4 CANADA WEST-CENTRAL (WC) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one video service using a full transponder (54 MHz) operating in a 0dB output power backoff mode.

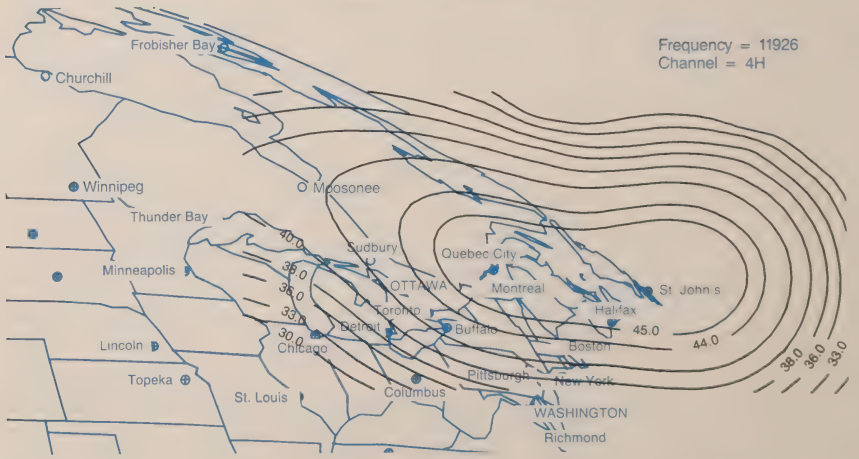
Figure 6
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/2 CANADA COMBINED WEST/WEST-CENTRAL (W-WC) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one video service using a full transponder (54 MHz) operating in a 0dB output power backoff mode.

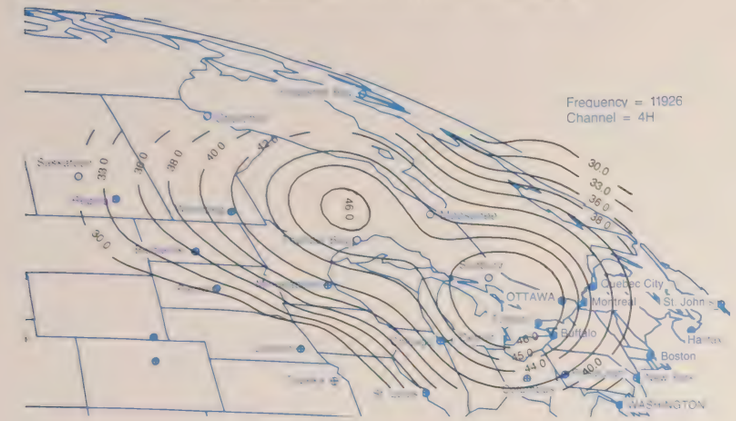
Figure 7
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/4 CANADA EAST (E) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one RF channel (27 MHz) video service operating in a 5dB output power backoff mode.

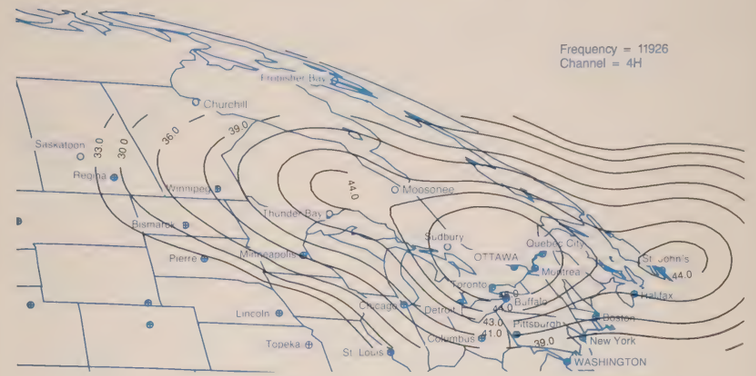
Figure 8
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/4 CANADA EAST-CENTRAL (EC) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one RF channel (27 MHz) video service operating in a 5dB output power backoff mode.

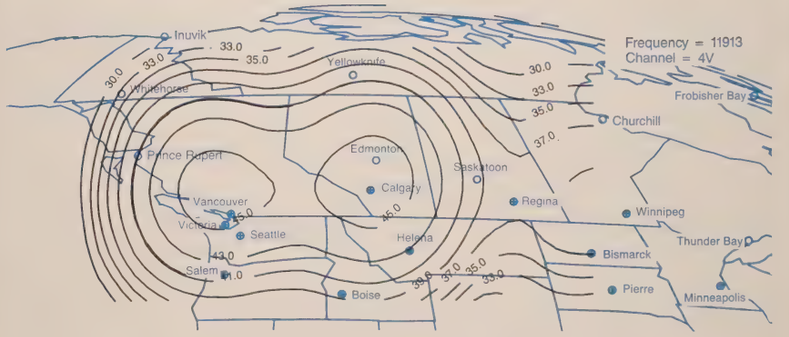
Figure 9
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/2 CANADA EAST-EAST CENTRAL (E-EC) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one RF channel (27 MHz) video service operating in a 5dB output power backoff mode.

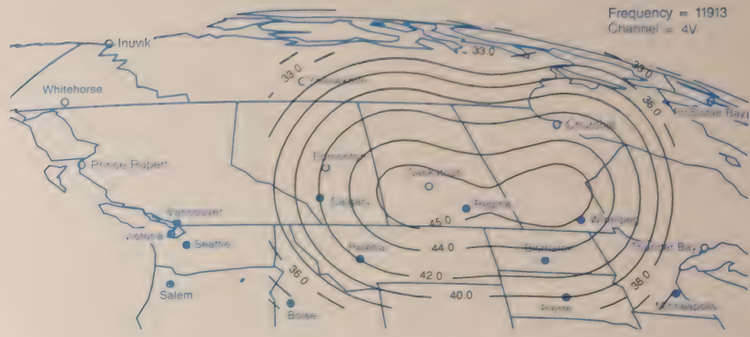
Figure 10
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/4 CANADA WEST (W) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one RF channel (27 MHz) video service operating in a 5dB output power backoff mode.

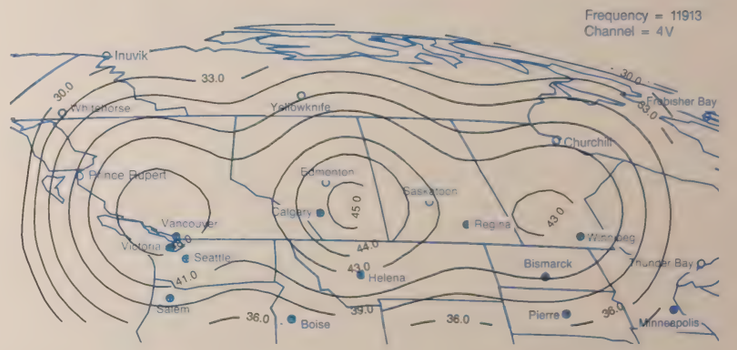
Figure 11
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/4 CANADA WEST-CENTRAL (WC) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one RF channel (27 MHz) video service operating in a 5dB output power backoff mode.

Figure 12
TYPICAL ANIK C TRANSMIT ANTENNA PATTERN 0° TILT
1/2 CANADA COMBINED WEST/WEST-CENTRAL (W/WC) BEAM



Satellite Longitude 117.5° W.
EIRP in dBW

The above EIRP contours are for one RF channel (27 MHz) video service operating in a 5dB output power backoff mode.

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Attachment 2

14/12 GHz
Propagation Statistics
for use with Anik C3

Telesat

Télésat Canada

The following information is to be used in conjunction with the calculations derived in the main part of this workbook. The tables provide the attenuation due to average rainfall and air moisture content for specific locations throughout Canada. These figures are based on historical data from Environment Canada. It must be noted that some locations presented here may be outside of Anik C3's nominal beam coverage and may not be able to receive good quality signals from Anik C3.

TABLE 1: MARITIME PROVINCES

Location	Rain attenuation, dB			Atmospheric Absorption, dB	Satellite Antenna Pointing Loss, dB	
	1%	0.5%	0.1%	Summer	¼ Canada Coverage	½ Canada Coverage
Charlottetown	0.5	0.8	2.5	0.3	0.4	0.4
Fredericton	0.6	1.1	2.4	0.3	0.3	0.6
Goose Bay	0.1	0.2	1.1	0.4	0.6	1.0
Gander	0.7	1.8	4.0	0.5	0.2	0.1
Halifax	1.0	1.6	4.0	0.3	0.6	0.6
St. John's (Nfld.)	1.6	2.6	6.0	0.6	0.3	0.3
Saint John (N.B.)	0.6	1.4	3.3	0.3	0.5	0.7
Sydney	0.6	1.7	3.7	0.3	0.4	0.4

Rain attenuation, atmospheric absorption loss, and satellite antenna pointing loss for cities in Maritime Provinces. St. John's (Nfld.) has an elevation angle of less than 10 degrees and the associated low elevation angle fadings are 0.3, 0.4, and 0.9 dB for 1%, 0.5% and 0.1% of the time, respectively.

TABLE 2: QUEBEC

Location	Rain attenuation, dB			Atmospheric Absorption, dB	Satellite Antenna Pointing Loss, dB	
	1%	0.5%	0.1%	Summer	¼ Canada Coverage	½ Canada Coverage
Chicoutimi	0.2	0.4	1.4	0.2	0.2	0.4
Fort George	0.0	0.1	0.5	0.2	1.1	0.9
Gaspé	0.4	0.7	2.3	0.3	0.2	0.4
Gagnon	0.2	0.4	1.9	0.3	0.4	0.8
Inukjuak	0.0	0.1	0.6	0.2	0.7	1.2
Montreal	0.3	0.5	2.0	0.2	0.5	0.3
Post de la Baleine	0.1	0.2	1.1	0.2	1.2	1.1
Povungnituk	0.0	0.1	0.6	0.3	0.7	1.2
Quebec City	0.4	0.7	2.5	0.2	0.3	0.3
Val d'Or	0.2	0.4	1.6	0.2	0.6	0.3

Rain attenuation, atmospheric absorption loss, and satellite antenna pointing loss for cities and communities in the province of Quebec.

TABLE 3: ONTARIO

Location	Rain attenuation, dB			Atmospheric Absorption, dB	Satellite Antenna Pointing Loss, dB	
	1%	0.5%	0.1%	Summer	¼ Canada Coverage	½ Canada Coverage
Cat Lake	0.2	0.4	1.4	0.2	0.5	0.5
Fort Severn	0.0	0.1	0.4	0.2	0.9	0.9
Geraldton	0.1	0.2	0.9	0.2	0.2	0.1
Kingston	0.4	0.7	1.9	0.2	0.5	0.4
London	0.3	0.5	1.9	0.2	0.3	0.6
North Bay	0.3	0.4	1.9	0.2	0.3	0.2
Ogoki	0.1	0.2	0.9	0.2	0.4	0.3
Ottawa	0.3	0.5	1.9	0.2	0.6	0.2
Sault Ste. Marie	0.3	0.5	1.8	0.2	0.1	0.3
Sioux Lookout	0.2	0.4	1.3	0.2	0.4	0.3
Sudbury	0.3	0.6	2.0	0.2	0.3	0.2
Thunder Bay	0.2	0.3	1.3	0.2	0.3	0.2
Timmins	0.2	0.3	1.4	0.2	0.5	0.2
Toronto	0.2	0.6	1.8	0.2	0.3	0.4
Windsor	0.3	0.6	2.1	0.2	0.5	0.8

Rain attenuation, atmospheric absorption loss, and satellite pointing loss for cities and communities in the province of Ontario.

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TABLE 4: MANITOBA AND SASKATCHEWAN

Location	Rain attenuation, dB			Atmospheric Absorption, dB	Satellite Antenna Pointing Loss, dB	
	1%	0.5%	0.1%	Summer	¼ Canada Coverage	½ Canada Coverage
Churchill	0.0	0.1	0.4	0.2	0.6	0.6
Dauphin	0.1	0.2	0.8	0.1	0.1	0.1
Moose Jaw	0.1	0.2	0.8	0.1	0.2	0.2
Prince Albert	0.1	0.2	0.7	0.2	0.2	0.3
Regina	0.1	0.1	0.6	0.1	0.2	0.1
Saskatoon	0.1	0.1	0.7	0.1	0.1	0.3
The Pas	0.1	0.2	0.8	0.2	0.2	0.2
Uranium City	0.0	0.1	0.3	0.2	1.0	0.7
Winnipeg	0.1	0.2	1.1	0.2	0.3	0.3

Rain attenuation, atmospheric absorption loss, and satellite pointing loss for major cities in Manitoba and Saskatchewan.

TABLE 5: ALBERTA AND BRITISH COLUMBIA

Location	Rain attenuation, dB			Atmospheric Absorption, dB	Satellite Antenna Pointing Loss, dB	
	1%	0.5%	0.1%	Summer	¼ Canada Coverage	½ Canada Coverage
Calgary	0.1	0.2	0.6	0.1	0.2	0.4
Edmonton	0.1	0.2	0.8	0.1	0.2	0.4
Ocean Falls	0.2	0.3	1.0	0.1	0.5	0.5
Prince George	0.1	0.2	0.9	0.1	0.3	0.3
Vancouver	0.2	0.3	0.9	0.1	0.3	0.4

Rain attenuation, atmospheric absorption loss, and satellite pointing loss for cities in Alberta and British Columbia.

TABLE 6: NORTHERN COMMUNITIES

Location	Rain Attenuation, dB			Atmospheric Absorption, dB	Satellite Antenna Pointing Loss, dB		Low Elevation Angle Fading Below Median Level, dB		
	1%	0.5%	0.1%	Summer	¼ Can.	½ Can.	0.1%	0.5%	1%
Arctic Bay	0.1	0.2	1.0	0.6	1.0	1.5	0.6	0.9	1.2
Cambridge Bay	0.0	0.1	0.5	0.3	1.0	1.2	—	—	—
Chesterfield Inlet	0.1	0.2	0.7	0.2	0.9	0.9	—	—	—
Eskimo Point	0.1	0.2	0.7	0.2	0.6	0.7	—	—	—
Frobisher Bay	0.1	0.1	0.9	0.4	1.0	1.2	0.1	0.3	0.5
Hall Beach	0.0	0.1	0.7	0.4	0.0	0.0	0.1	0.3	0.5
Inuvik	0.0	0.1	0.5	0.3	1.0	1.3	—	—	—
Pangnirtung	0.1	0.2	1.2	0.6	1.0	1.5	0.6	0.9	1.2
Pond Inlet	0.1	0.2	1.3	0.7	1.0	1.5	0.6	0.9	1.2
Resolute Bay	0.1	0.2	1.1	0.3	1.0	1.5	0.6	0.9	1.2
Spence Bay	0.0	0.1	0.5	0.6	1.0	1.2	—	—	—
Tuktoyaktuk	0.0	0.1	0.5	0.3	1.0	1.5	—	—	—
Whitehorse	0.1	0.2	1.1	0.2	0.7	1.6	—	—	—

Rain attenuation, atmospheric absorption loss, satellite pointing loss, and low elevation angle fading for northern communities.

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